UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics

UTILIZATION OF COTTON AND OTHER MATERIALS IN CORDAGE AND TWINE

By Robert B. Evans, Assistant Agricultural Economist and
R. J. Cheatham, Principal Cotton Technologist

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This report is the twenty-fourth of a series by the Bureau of Agricultural Economics relating to the utilization of American cotton. Those issued are:

A Partial List of Uses of American Raw Cotton
Cotton Bags in the Wholesale Grocery Trade
(Out of print. See sixth publication listed)
Farm Uses for Cotton and Its Products
Cotton Bagging for Cotton
Domestic Mill Consumption of American Cotton by Grades and Staples
Cotton Bags and Other Containers in the Wholesale Grocery Trade
Cotton Bags in the Fertilizer Industry
Quality of the Cotton Spun in the United States (Year ending July 31, 1928)
The Use of Cotton Bags as Consumer Packages for Potatoes
Cotton Consumption in Power Laundries of the United States, 1928
Cotton Picking Sacks, Cotton Picking Sheets, and Tarpaulins Used on Cotton Farms of the United States
Staple Length of Foreign-Grown Cotton Consumed in the United States, 1928-1931
Use of Cotton Bags and Other Containers in Flour Mills of the United States - 1931
Comparative Advantages of Jute and Cotton Bagging for American Cotton Bales
Use of Cotton Bags and Other Containers in Flour Mills of the United States - 1932
Effect of Certain Bale Covers on the Spinning Behavior of Cotton
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Cotton Bags and Other Containers in Flour Mills of the United States, Years Ended June 30, 1933 and 1934
Utilization of Cotton and Other Materials in Fertilizer Bags
Cotton Bags and Other Containers in Flour Mills of the United States, Years Ended June 30, 1933 and 1934
Utilization of Cotton and Other Materials in Cordage and Twine

The studies reported in this series are a part of a program of research of the United States Department of Agriculture and cooperating agencies on the utilization of American cotton.

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INTRODUCTION

The demand for American cotton is a reflection of the demand for the thousands of products into which it is manufactured. Consequently, a thorough understanding of this demand involves a knowledge of the raw-material requirements of these products and of the economic and technological factors affecting their use.

In order to secure a fund of information on this subject, the Bureau of Agricultural Economics has made a series of studies analyzing certain uses and groups of uses of cotton. The present study has three principal aims: (1) To determine the quantity of cotton and other fibers used in cordage and twine; (2) to obtain quantitative information on the grade and staple of lint cotton and on the types of cotton waste used in cotton cordage and twine; and (3) to determine the major factors affecting the use of cotton for this purpose.

Utilization of cotton in cordage and twine is of particular interest because cotton is here used as a cord rather than as a fabric. On the basis of census data, it is estimated that roughly three-fourths of the total quantity of cotton consumed in the United States is made into the various types of cotton woven goods more than 12 inches in width. Another 12 percent, approximately, is made into other kinds of fabric, chiefly knit goods, or is mixed with other fibers in rayon, silk, and woolen goods. Of the nonfabric uses, thread, twine, and cordage require less than 5 percent of the total cotton used, twine and cordage together requiring about 3 percent. The remaining 8 percent is used chiefly in battings, waddings, and mattress felts, and similar uses, and consists largely of cotton waste removed during processing of other products.

1/ Acknowledgment is made of the assistance rendered by various cordage and twine manufacturers and by the Cordage Institute, whose cooperation made possible the completion of this survey and report. Acknowledgment also is made of the assistance given by certain staff members of the U. S. Department of Agriculture and the U. S. Tariff Commission.
2/ Formerly members of the Bureau of Agricultural Economics, now members of the Southern Regional Research Laboratory, Bureau of Agricultural Chemistry and Engineering.

Although the quantity of cotton used in cordage and twine is small as compared with the size of the cotton crop, it is relatively large as compared with quantities consumed in most of the other individual uses of cotton and also as compared with quantities of other fibers used in cordage and twine. There are some 1,500 plants from which fibrous substances may be derived but not more than 25 are used commercially in the manufacture of textiles and cordage. Principal fibers used in the manufacture of cordage and twine in this country number 11; namely, sisal, henequen, abaca' (Manila fiber), phormium (New Zealand fiber), istle (Tampico fiber), cantala (maguey), Mauritius hemp (pitera), jute, hemp, flax, and cotton. Paper, although not a fiber, also is used in the manufacture of twine. Although cotton is not considered a "cordage fiber" in the same sense as are certain other fibers like hemp, it is used in the United States in greater quantities in the manufacture of twine and cordage combined than any other fiber except henequen. In 1937, estimated consumption of cotton in twine and cordage aggregated 118 million pounds, the equivalent of approximately 248,000 net-weight bales.

Information used in this report was derived in part from a questionnaire sent to manufacturers, in which information was requested on cotton utilization in cordage and twine. Replies were obtained from 54 manufacturers, representing 65 percent of the total cotton twine production and 32 percent of the total cotton cordage production in 1937. Additional information has been derived from the Census of Manufactures and also from various other official and trade sources.

History of Cordage and Twine

The act of combining two or more comparatively weak filatel elements, through twisting, into a comparatively strong yarn, cord, or thread, may be safely reckoned as one of the first technical achievements of man. Every civilization yet discovered, no matter how elemental, has been proficient in this practice. The idea of cordage is so universal that it might well have had multiple origins, the idea occurring to many men in many parts of the world, separated by great reaches of time. 3/

Primitive people generally had access only to the materials at hand for cordage purposes; and, as a result, almost every conceivable material, both animal and vegetable, was used for this purpose in different parts of the world. Cotton, for example, is known to have been used for cordage by both the aborigines of the southwestern States 4/ and by the people of India 5/ before our present civilization.

3/ Crawford, M. D. C., The Heritage of Cotton: The Fibre of Two Worlds and of Many Ages.

4/ Jones, Volney H., A Summary of Data on Aboriginal Cotton in the Southwest. University of New Mexico Bulletin, Symposium on Prehistoric Agriculture, October 15, 1936, p. 51.

5/ Royle, J. F., The Fibrous Plants of India Fitted for Cordage, Clothing, and Paper, 1855, p. 2.

With the gradual increase in trade between countries, certain fibers gained prominence as being particularly suitable for cordage purposes. Until the last century, the most important of these was true hemp. Hemp was used in cordage on the ships of Syracuse in 200 B. C. and, according to Pliny, was in common use for the same purpose among the Romans of the first century.6/ Flax also was used for cordage in ancient and midieval times but its use for this purpose was comparatively limited as compared with its utilization in woven fabrics.

Although jute had long been used in India for cordage and other purposes, it did not become popular in other countries until about 1830, when improvements in spinning machinery made possible its processing on a commercial scale. Abaca' or Manila fiber also was introduced to commerce about the same time, coming into widespread use a few years later as the result of the stoppage of Russian hemp supplies during the Crimean War. Other fibers now used in the manufacture of cordage and twine were also introduced into world trade during the nineteenth century, no new materials having been made available in commercial quantities since 1900.7/

In the United States, the commercial production of cordage began with the establishing of a ropewalk in Boston in 1642.8/ By 1792, ropewalks were in operation in all of the New England States, as well as in New York, Philadelphia, Maryland, and Virginia.9/ The development of the American merchant marine between the American Revolution and the Civil War provided the impetus for a continued expansion of this industry.

Before 1830, rope manufacturing was done by hand. Twisting of the fibers was accomplished by a man walking backward down the "walk," spinning from the fiber which was strung about his waist. The twist was imparted to the rope by a wheel, which was at first turned by hand but was later actuated by horse or water power. Soon after 1830 the modern factory system began to replace these methods of making rope and the necessary twist was imparted by rapidly rotating machinery. Invention of the self-binding harvester and the subsequent demand for binder twine opened a large new market for the cordage industry after 1875.10/ In addition, demands for other types of twine and cordage from domestic agriculture and industry increased greatly.

Generally speaking, cotton cordage and twine have been manufactured in separate mills from those manufacturing cordage and twine from other fibers, owing to differences in the machinery required for spinning yarns. Little is known in regard to how long cotton cordage and twine

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6/ Woodhouse, T., and Kilgour, P., Cordage and Cordage Hemp and Fibres, London, 1919, p. 3.
7/ Oakley, F. I., Long Vegetable Fibers, London, 1928, Introduction.
8/ American Encyclopedia. Article on cordage.
9/ These Ropemakers Helped Start Fight for Independence in '76. Cordage Mag., October 1938, p. 24.
10/ American Encyclopedia. Article on Cordage.

have been manufactured and used in this country, but it is thought that they were first imported from England for use principally on sailing vessels. Cotton twines for tying purposes are said to have originated as an adaptation to a new use for yarns already being manufactured for carpet weaving and for sewing sails. Several establishments manufacturing seine twine, which is used largely for fishing purposes, began operations more than one hundred years ago,[11] and nets were manufactured from domestically produced twines after about 1844.[12]

Before 1900 the great proportion of cotton twine used for tying purposes in this country was of 3, 4, and 5-ply, or the sizes of greatest footage per pound. The introduction of polished cotton twine in 1895 and the appearance on the market of heavier ply cotton twines about the same time, have resulted in cotton twines being used for purposes for which only jute, hemp, and flax twines formerly were available. This change, with the accompanying increase in commercial and industrial activity since 1900, has resulted in a tremendous increase in the use of cotton twines.

Efforts have been made from time to time to standardize specifications and to eliminate unnecessary varieties of cordage and twine under the Simplied Practice Program of the National Bureau of Standards. As a result, recommendations were adopted between 1928 and 1932 which provided standardized specifications for hard-fiber twines, jute twines, flax and hemp twines, and polished cotton twines.[13] In the case of polished cotton twines an elimination of approximately 75 percent of the number of constructions was effected. As yet there are no standardized specifications for the various types of cordage or for unpolished cotton twines.

Production of cotton twine and cordage is concentrated at present in the States of Georgia, North Carolina, New Jersey, Maryland, Texas, and Tennessee, with smaller amounts produced elsewhere. Most of the plants manufacturing twine and cordage from fibers other than cotton are located in the States of New York, Massachusetts, Pennsylvania, New Jersey, and Ohio, but there are a few plants elsewhere, including a scattering of prison binder-twine factories in the Middlewest.

In general, twine and cordage plants perform all manufacturing processes required to transform the raw fiber into the finished product. However, some cotton twine and cordage plants manufacture their product from purchased yarns, particularly small mills producing specialties.

11/ Compiled from information in Davison's Cordage, Twine and Duck Trade, 1938, Davison Publishing Company, Ridgewood, N. J.
12/ Encyclopedia Britannica. Article on nets.
13/ United States Department of Commerce, Bureau of Standards, Washington. Simplified Practice Recommendations R92-28, R110-29, R124-31, R136-32.

Materials Used in Cordage and Twine

With the exception of cotton and minor quantities of flax and hemp, all fibers used in this country in the manufacture of cordage and twine are imported. These fibers originate in a number of different countries and under a variety of natural environments. Their use in the various types of twine and cordage is controlled both by their physical adaptability to specified requirements and by the comparative cost at which they are available.

Fibers used for twine and cordage, other than cotton, may be divided into two groups: (1) Hard or "leaf" fibers which are derived from the tissues of leaves and leaf stems of plants and (2) soft or "bast" fibers which are derived from the bast tissues of plant stems. Hard fibers used extensively include henequen, sisal, abaca' (Manila hemp), istle, cantala (maguey), and phormium (New Zealand fiber). Soft fibers include jute, hemp, and flax. Although cotton is a seed fiber it is grouped for statistical purposes with the soft fibers in this report.

Henequen.- In point of quantity, henequen fiber is the most extensively used fiber in twine and cordage manufacture in this country, owing to the large amounts used in the manufacture of binder twine. Henequen consists of strands of fiber from 3 to 5 feet long, of a nearly white or yellowish white color, which are derived from the leaves of the henequen plant (Agave fourcroydes). It is a strong, coarse fiber which is harder than sisal or abaca'. Production of henequen is largely restricted to the Yucatan Peninsula of Mexico, and to Cuba, although small quantities are produced in Salvador and in other areas in Mexico. About two-thirds of the Mexican production is exported to the United States.14/ Besides being used for binder twine, it is used in small ropes, wrapping twines, and in bags.

Sisal.- Closely allied with henequen in structure and use is sisal, a fiber derived from the sisal plant (Agave sisalana). This fiber is softer, less woody in texture, and lighter in color than henequen, and usually commands a higher price. Its principal use in the United States is in wrapping twines, but it also is used to a varying extent in binder twine and small ropes. In addition to cordage and twine uses, it is used to some extent, either in this country or elsewhere, in floor coverings, paddings for upholstery and mattresses, plaster board, bags, paper, and so forth.

The most important sisal-producing countries are British East Africa and the Dutch East Indies, but quantities also are produced in other sections of Africa and in Haiti. Sisal production has increased more than eightfold since 1920, in marked contrast to production of henequen which has remained approximately stationary.

14/ Average 1935-37.

Table 1.- Average annual production of designated fibers in the World and in the United States and percentage of World production consumed in the United States, 1934-38.

Fiber	World production 1/	United States production 2/	Consumed in the United States: Total 3/	Consumed in the United States: Percentage of world production
	Million pounds	Million pounds	Million pounds	Percent
Hard fibers:				
Henequen	225	0	159	71
Sisal	507	0	147	29
Abaca'	382	0	88	23
Other hard fibers	70 4/	0	21 5/	30
Total	1,184	0	415	35
Soft fibers:				
Cotton	14,200	6,077	3,090	22
Jute	3,924	0	777	20
Flax	1,713	1	41	2
Hemp	819	1	3	0 6/
Total	20,656	6,079	3,911	19

1/ Compiled from official publications, reports of International Institute of Agriculture, and from annual reviews of Wigglesworth & Company, Ltd.
2/ Compiled from "Cotton Production and Distribution" and from records of the Bureau of Plant Industry.
3/ As follows: Cotton, mill consumption; abaca', "other hard fibers," and hemp, quantities of raw fiber made available for consumption; sisal, henequen, jute, and flax, quantities of raw and manufactured fiber made available for consumption.
4/ Includes phormium, Philippine cantala (maguey), Mauritius hemp, and istle.
5/ Includes phormium, maguey, istle.
6/ Less than 0.5 percent.

Abaca'.- Abaca' or Manila fiber is often termed the best cordage fiber because it is longer, stronger, and more durable than the other hard fibers. Best grades of this fiber are of a light buff, lustrous color, and consist of fine, even strands 6 to 12 feet long. The fiber is stripped from the overlapping leaf stems which form the stock of the abaca' plant (Musa textilis), a type of banana or plantain plant, the yield of fiber aggregating only about 1-1/2 percent to 2 percent of the weight of the green material. Abaca' is cultivated in the Philippine Islands and to a limited extent in Sumatra and Borneo. In addition, small quantities now are being produced experimentally in Panama. The United States purchases 20 percent to 27 percent of the abaca' produced

in the Philippines, chiefly of the higher grades. Abaca' is regarded as the most satisfactory material known for making ships' ropes, hoisting ropes, and transmission ropes. It is used in the manufacture of wrapping twines and paper, and has been used in the past in the manufacture of binder twine.

Other hard fibers.- Cantala (maguey), from the leaves of the cantala plant (Agave cantala), cultivated in the Philippine Island and in Java; phormium (New Zealand fiber), from the leaves of the harakeke lily (Phormium tenax) growing both wild and cultivated in New Zealand and under cultivation at St. Helena; Mauritius hemp, from the leaves of the pitera plant (Furcraea gigantea) on the Island of Mauritius; and istle or Tampico fiber, extracted from the leaves of several species of Mexican plants which are somewhat similar to the henequen plant, are other hard fibers used in the manufacture of cordage and twine. They are used for this purpose in limited quantities only, usually mixed with other hard fibers, or with jute, and their consumption varies considerably from year to year with cost and availability of other fibers.

Soft fibers.- In comparison with hard fibers, soft fibers collectively occupy a less important position in the manufacture of twine and cordage in the United States, only about 20 percent of the cordage and 35 percent of the twine (including binder twine) being made from these materials. With the exception of hemp, utilization of these fibers in cordage and twine is secondary importance as compared with their utilization in textiles.

Table 2.- Estimated consumption of designated fibers in the manufacture of twine and cordage in the United States during 1935 and 1937. 1/

Fiber	1935	1937
	Million pounds	Million pounds
Hard fibers:		
Henequen	140	119
Sisal	62	82
Abaca' (Manila)	76	84
Istle	9	10
Other	5	5
Total	292	300
Soft fibers:		
Cotton	89	118
Jute	41	40
Flax	2	3
Hemp	3	3
Total	135	164

1/ Rough estimates based on production and consumption data in Census of Manufactures and on other information.

Cotton.- Cotton is, of course, the most important textile fiber and in quantity produced and consumed exceeds all other plant fibers combined. It is also the most important material used in cordage and twine manufacture in this country from the standpoint of value, and is second only to henequen in quantity used. Although the cotton used in cordage and twine is usually entirely of domestic origin, it is possible that small amounts of foreign cottons have been used in domestic cordage and twine manufacture during some years.

Jute.- In quantity produced, jute is second only to cotton as a plant fiber. Jute consists of soft or bast fibers from two closely related plants, the round-pod jute (Corchorus capsularis) and long-pod jute (Corchorus olitorius), both of which are cultivated in India, particularly in Bengal. The fibers are light yellow to nearly white or bright copper to deep slate, changing with age to dingy brown or gray. Jute is relatively weak as compared with other bast fibers and is not very resistant to moisture conditions. Roughly 80 percent of the jute imported into the United States is in manufactured form, principally as burlap. Of the raw fiber imported, about 80 percent is manufactured into bagging, webbing, carpets, yarns, and roves for various uses, and about 20 percent into twine. Utilization in cordage is inconsequential.

Flax.- Although flax is one of the most important plant fibers its use in the United States is relatively small, comprising only 2 percent of the World's production. Flax is a soft or bast fiber obtained from the inner bark of the flax plant (Linum usitatissimum), which is cultivated for fiber principally in Russia and the Northern European countries. In North America, small amounts are grown in Canada and in Oregon. The fiber is of dark gray, bluish green, or cream white color, depending on preparation, makes a strong light strand, and withstands moisture well.

About two-thirds of the flax imported into the United States is in the form of manufactured or semimanufactured goods. Of the raw fiber manufactured in this country, roughly 25 percent is made into twines and fishlines, and 75 percent into thread, towelings, and other woven goods. An inconsequential quantity of cordage also is made from this material.

Hemp.- Although hemp was the most important fiber used in cordage and twine until about the middle of the last century, its use at present is relatively small. It is a coarser, less flexible fiber than flax, but is strong and durable, though not so resistant to salt water as abaca'. It is derived from the inner bark of the hemp plant (Cannabis sativa), which is cultivated chiefly in the Soviet Union, Italy, Yugoslavia, Roumania, and Chosen, and to a minor extent in Kentucky and Wisconsin in this country. Principal uses at present are in wrapping, mattress, sewing, and broom twines, in halibut lines, and in hemp cordage used on ships.

The Manufacturing Process

Although differing somewhat with the kind of fiber, the process by which raw fiber is converted into cordage and twine consists essentially of three operations: (1) Preparation of the fiber, (2) spinning, and (3) twisting or braiding the required number of yarns into the finished twine or cordage. In the preparation processes, the fibers are separated, cleaned of foreign matter, straightened and laid parallel, and overlapped, so as to compose a "sliver" or "roving" of the required size for spinning. With fibers other than cotton, a softening or lubricating emulsion is added during this process so that the fibers will work more easily on the spinning machines, and to improve certain properties of the product.

Following preparation, the sliver or roving enters the spinning process where "twist" is imparted and the "yarn" is spun. If a twine of single-thread construction is being made, the manufacturing process is completed at this point. Otherwise the yarns are "twisted" or "formed" into strands which may be used in this form or may be twisted again, or braided, with other strands to form twine or cordage.

During one or more of the above operations, the cordage or twine may be oiled, tarred, polished, or finished with starches and waxes, or otherwise treated for the purpose of preventing rotting, increasing strength or smoothness, or preventing bacterial action. These treatments increase the weight of the product by 2 percent to 15 percent. As a final step the product is wound on cones, balls, tubes, or reels, or is put up in skeins, coils, etc.

A fiber loss ranging from roughly 6 percent to 15 percent or higher, by weight, occurs during the manufacturing process, the loss depending on the type and grade of fiber used and on the grade of product being manufactured. All but a fraction of 1 percent of this loss occurs prior to spinning. The average percentage of fiber loss in manufacture of cordage and twine is shown in the following figures.1/

Fiber	Percentage of loss
	Percent
Manila	6
Sisal	6
Henequen	10-12
Istle	12-15
Jute	10-15
Flax	8
Hemp	15-20
Cotton	15

1/ Rough average differences between weight of raw fiber used and weight of fiber content of product. Based on estimates of manufacturers.

CORDAGE AND TWINE PRODUCTS AND USES

Cordage and twine are manufactured for a wide variety of uses and consequently they range in size from large ropes, 6 inches in diameter, suitable for towing vessels, to thin cotton twines with a breaking strength of only 3 pounds. Requirements for individual uses are met by making a choice of fibers, fiber qualities, and constructions, paying attention at all times to the necessity of finding a product which will perform its task adequately and at minimum cost.

One of the most important single characteristics of cordage and twine, so far as gauging their physical suitability for various uses is concerned, is breaking strength. In attempting to classify these products, we therefore may note that abaca' (Manila) cordage and twine are generally used when maximum strength is required, followed successively by cordage and twine made of sisal and henequen, hemp and flax, and cotton and jute, as breaking strength becomes of less importance. It should be stressed, however, that breaking strength does not always indicate the strength under actual use conditions, since cordage and twine of some types lose more strength when knotted or flexed than others. It also should be stressed that breaking strength is only one standard for comparison and that other conditions such as durability, flexibility, softness, and weight, are often of equal or greater importance. For instance, the flexibility and softness of cotton cordage are of greater importance in Venetian-blind cords than the greater strength of other types of cordage.

During 1937, production of all types of cordage and twine in the United States totaled 496 million pounds valued at 74 million dollars. Of this total, 315 million pounds were made of abaca', sisal, henequen, and other hard fibers; 100 million pounds of cotton; 50 million pounds of jute, hemp, flax, etc.; and 31 million pounds of paper. Principal products manufactured, in percentages of total production and value, are shown in table 3.

Table 3.- Production of specified types of twine and cordage in the United States during 1937 in percentages of total production and value.

Twine and cordage	Quantity produced	Value
	Percent	Percent
Hard-fiber binder twine	32	16
Other hard-fiber twine	11	8
Hard-fiber cordage	21	22
Total	64	46
Cotton twine	15	26
Cotton cordage	5	10
Total	20	36
Jute, flax, hemp, etc., twines	10	14
Hemp and other cordage	1/	1
Total	10	15
Paper twine, total	6	3
Grand total	100	100

1/ Less than 0.5 percent.

Compiled from Census of Manufactures.

Cordage Products

Production of cordage comprised 27 percent of the total production of cordage and twine during 1937 and totaled 132 million pounds, valued at 24 million dollars. Cordage is defined as "ropes and cords in general" 15/ and is distinguished from twine, according to usual acceptance, in that it is three-sixteenths of an inch in diameter or greater. Types of cordage manufactured and their unit value, from the standpoint of fibers used, are given in table 4.

Table 4.- Production and value per pound, by types, of cordage manufactured in the United States during 1937.

Kind	Production		Average value per pound 1/
	Quantity	Percentage of total all types	
	Million pounds	Percent	Cents
Abaca' (Manila), total or average	88.1	67	16
First grade (pure)	56.5	43	16
Second and lower grades (pure)	19.0	14	14
Higher grades and specialities	12.6	10	19
Sisal and henequen, total or average	7.9	6	10
First grade	2.6	2	11
Second and lower grades	5.3	4	10
All other hard fibers, sisal specialties, and abaca' mixed with other hard fibers	8.6	6	16
Total or average, all hard fibers	104.5	79	16
Hemp	.2	2/	38
Cotton	27.2	21	26
All other	3/	3/	--
Total or average, hemp and cotton	27.4	21	26
Total, all types	132.0	100	--

1/ Average selling value at factory.
2/ Less than 0.5 percent.
3/ Quantity not reported.

Compiled from Census of Manufactures.

15/ New Standard Dictionary.

Abaca' cordage.- Production of abaca' (Manila) cordage exceeds that of all other types of cordage combined both in quantity and total value. This type of cordage is used for the majority of general rope-requiring purposes, particularly where maximum strength and durability is needed as in marine cordage, hoisting and transmission ropes, and drilling cables. It is manufactured in various grades, ranging from "yacht" and "bolt" ropes which are made from the finest fiber, through first-grade or "standard Manila," to types known as second-grade and third-grade Manila. Most abaca' cordage is of 3-strand construction with an oil content of from 10 percent to 15 percent, but there are other constructions and specially treated types for special purposes. A large number of sizes are manufactured ranging from three-sixteenths of an inch to 4 inches or more in diameter. (Table 5.) As is noted in table 4, two-thirds of all cordage manufactured in 1937 was made from abaca'.

Table 5.- Diameter, length per unit of weight, and breaking strength of designated cordage. 1/

Type	Diameter		Feet per pound		Breaking strength	
	Finest size	Coarsest size	Finest size	Coarsest size	Finest size	Coarsest size
	Inches	Inches	Feet	Feet	Pounds	Pounds
No. 1 Manila 2/ 3/	3/16	4	67	0.23	450	105,000
Hemp, small tarred ropes	-	-	360	10.0	105	2,400
Cotton rope	1/8	1	200	3.5	120	5,100
Cotton, braided sash cord	3/16	3/8	66	19.5	225	560

1/ Indicating specifications for finest and coarsest sizes of each type in common use, as indicated by Federal Specifications.
2/ Applies to 3-strand rope.
3/ No specifications are available for other types of hard-fiber cordage, but according to the trade they have the following approximate tensile strengths, considering No. 1 Manila's strength as 100 percent: Yacht and bolt (Manila), 110 percent; No. 2 Manila, 90 percent; No. 1 sisal (Java sisal and comparable fibers), 75; No. 2 sisal, (henequen and comparable fibers), 65.

Other hard-fiber cordage.- An additional 12 percent of the cordage manufactured during 1937 was made from hard fibers other than abaca'. Of this quantity, about half consisted of sisal and henequen cordage and about half of cordage made from "all other hard fibers, sisal specialties (wire-rope centers, etc.) and abaca' mixed with other hard fibers." These types are available at a lower cost than similar abaca' cordage and serve purposes in which the higher strength and durability of abaca' are not imperatively needed. Special types include lariat rope, raft ropes for tying logs together, halter ropes for animals, and clothes lines.

Hemp and jute cordage.- Minor quantities of cordage also are made from hemp and jute. Hemp cordage is generally tarred and although it possesses excellent qualities it is expensive. It once was the dominant type of cordage, but its use in this country at present is confined mainly to small auxiliary ropes on board ships. Sizes in common use in the United States range from less than three-sixteenths of an inch to about one-half inch in diameter with breaking strengths of from about 105 to 2,400 pounds.

Jute cordage is much less expensive than hemp and has been used in the past for general purposes requiring small ropes. Its lack of durability, low tensile strength, and poor resistance to moisture greatly limit its use, and only a small quantity now is manufactured.

Cotton cordage.- In addition to the types discussed above, a considerable quantity of cotton cordage is produced. Principal uses of cotton cordage are as clothes lines, windowsash cords, and plot lines. However, a large proportion of the production is used for a variety of purposes like awnings, holding up fishing nets, on shipboard, and in various manufactured articles. This type of cordage is discussed in greater detail later.

Binder Twine

Binder twine is single-ply, hard-fiber twine used with binders for automatically tying bundles of the various small grains, flax, and grass-seed crops, and corn during harvesting. Owing to its unique use in harvesting these crops, it is used in larger quantities in this country than all other types of twine combined. During 1937, production of binder twine totaled 158 million pounds or 32 percent of the total production of cordage and twine. Of this quantity, 43 million pounds was manufactured by State-owned prison industries.

Nearly all of the binder twine produced domestically at present is made of henequen or sisal. Other hard fibers, including abaca', istle, sunn, and phormium, also have been employed for this purpose at times when price and other considerations favored their use. Henequen and sisal are usually the chief component fibers of the two principal grades of domestic binder twine, which are known as "White Sisal" and "Standard", and which have a length per unit of weight of 500 feet to the pound. Binder twine in other grades averages up to 650 feet to the pound.

In the manufacturing process, binder twine is spun on "long line" machinery directly from the sliver of the various hard fibers. The twine is oiled when spun, resulting in the finished product having a nonfiber content of 15 percent to 18 percent. It is sold in balls, weighing 5 and 8 pounds each, packed in burlap bags of approximately 50 pounds gross weight.

Twine Other Than Binder Twine

Production of all types of twine other than binder twine comprised 42 percent of the total production of cordage and twine during 1937, totaling 207 million pounds valued at 38 million dollars. Soft-fiber twine made up the bulk of this production although hard-fiber twine was of greater importance than in former years. Cotton twine was the most important single type produced, comprising one-third of the total quantity produced and one-half of its value. Production and average value per pound of the various types are as given in table 6.

In general, the finest, lightest twines are made from cotton and the coarsest, heaviest twines from hard fibers. Jute, flax, and hemp twines occupy intermediate positions between the two, overlapping in size with the coarser cotton twines and the finer hard-fiber twines. Some indication of the relationship between twines made from various fibers is indicated by table 7, showing the limits of breaking strength and length per unit of weight for twines in common use. It should be noted that as this table does not take into consideration other important factors, it does not fully indicate competitive relationships between twines.

Hard-fiber twines.- In comparison with other twines, hard-fiber twines are used when a comparatively high strength is the outstanding requirement, as for heavy, bulky packages. A considerable variety of these twines are manufactured, ranging from 750 to 23 feet per pound in length per unit of weight and from 85 to 1,550 pounds in breaking strength.

Hard-fiber twines are divided into five classes in accordance with the kind of fiber used, but with the qualification that the class designations are "not intended to convey the impression" that they "are made exclusively from the fiber named."16/ More than three-fourths of the production is of the Class II or Java sisal grade and an additional 15 percent is of the Class IV (Mexican sisal) grade or of the Class V grade which is designated as "containing at least 65 percent of istle, and worked on hard-fiber machinery." The remainder consists of small quantities of Class I (Manila), Class III (New Zealand), and other hard-fiber twines, including those which are paper-covered.17/

Jute twines.- Occupying a position between hard-fiber and cotton twines in size and breaking strength, jute twines are available for a large range of packaging requirements. In general the coarser jute twines are comparable in tensile strength with the finer sizes of

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16/ Bureau of Standards: Hard Fiber Twine and Loth Yarn. Simplified Practice Recommendation, R-92-38, 1938.

17/ Individual sizes of hard-fiber twines are designated by the size of yarn used in feet per pound, and by the number of ply as, for instance, "900 feet - 2 ply", etc. They also are designated as "twisted" or "laid," "laid" indicating that the yarns were given an extra twist while being plied into twine. The extra twist is to prevent the twine from untwisting.

Table 6.- Production and value per pound of twines (other than binder twines) manufactured in the United States during 1937

Kind	Production		Average value per pound
	Quantity	Percentage of total	
	Million pounds	Percent	Cents
Hard fiber:			
Class I (Manila)	0.1	1/	20
Class II(Java sisal) 2/	42.4	21	11
Class IV(Mexican sisal)			
Class V(Containing at least 65 percent istle and worked on hard-fiber machinery)	7.9	4	10
Other	2.5	1	13
Total hard fiber	52.9	26	-
Soft fiber:			
Cotton	73.3	35	26
Flax 3/	2.1	1	4/ 35
Hemp	.9	1/	31
Jute	26.0	13	16
Jute and istle, mixed	14.7	7	11
Flax and hemp, hemp and jute mixed	2.4	1	27
Other soft fiber	3.7	2	13
Total soft fiber	123.1	59	-
Paper	30.6	15	6
Total twine	206.6	100	-

Compiled from Census of Manufactures, 1937.

1/ Less than 0.5
2/ Includes small quantity of Class III, New Zealand.
3/ Includes 131,470 pounds of "linen fishline."
4/ Value of flax twine only; "linen fishline" valued at $6.44 per pound.

Table 7.- Breaking strength and length per unit of weight of designated twines. 1/

Twine	Feet per pound		Breaking strength	
	Finest size	Coarsest size	Finest size	Coarsest size
	Feet	Feet	Pounds	Pounds
Cotton, unpolished, first grade	6,834	669	6	69
Cotton, unpolished, second grade	4,830	717	8	48
Cotton, polished	4,820	250	11	160
Cotton, seine (unpolished)	3,460	65	12	600
Flax, unfinished	2,280	1,140	32	80
Hemp, fine, finished	1,710	243	27	228
Hemp, fine, unfinished	1,283	570	37	100
Jute, wrapping, sail, etc.	1,710	285	20	115
Jute, finished	1,620	65	25	450
Jute, tube rope, bale rope, etc.	425	60	65	420
Hard-fiber, Class I (Manila)	432	153	115	385
Hard-fiber, Class II (Java Sisal)	750	23	85	1,550
Hard-fiber, Class III (New Zealand)	510	90	102	466
Hard-fiber, Class IV (Mexican sisal)	510	23	92	1,160
Hard-fiber, Class V (Istle, mixed)	405	23	90	930

1/ Indicating specifications for finest and coarsest sizes of each type in common use. Breaking strength for flax, hemp, and jute twines are minimum requirements. For other twines they are approximate averages. Data for cotton twines compiled from trade catalogs and price lists. Data for other twines compiled from Simplified Practice Recommendations of the Bureau of Standards.

hard-fiber twines, although they are not so strong as the coarsest hard-fiber twines. Likewise, fine jute twines compare in yardage per pound with medium and coarse cotton twines, although they do not have so great a yardage per pound as the finest of the cotton twines.

About 25 percent of the total production of jute twines is "finished" or polished with a sizing solution. This process cements the fibers together and glazes the outside of the twine, resulting in improved smoothness and appearance. Finished jute twines are used principally for tying packages, the finer sizes being used on small retail and parcel post containers and the coarser sizes on heavier packages, such as wholesale and express containers. They also are used for tying tags, fastening springs in furniture, stringing hems and sides of bacon in meat-packing establishments, and for other varied purposes.

Unpolished jute twines are designated by names which are indicative of their original use. For instance, finer unpolished twines are designated as "wrapping," "sail," "sewing," "miller's," or "baling" twine, while the intermediate sizes are known as "tube rope" and the heavier sizes as "paper-maker's bale rope," "pipe cord," or "hide rope."18/ Tube rope was originally made for bundling pipe and metallic tube but most of the demand for this product is now for bundling paper, corrugated boxes, magazines, and for tying automobile tires, furniture, clothing, packages, and so forth. Greatest demand for the heavier twines is still from paper manufacturers but these twines are used also for wrapping commodities comparable to those on which tube rope is used.

Hemp and flax twines.- Hemp and flax twines are manufactured in about the same size and weight range, roughly, as fine and medium-size jute twines but offer considerably greater strength, durability, and flexibility. However, they are higher priced than other twines and are used only when their special qualities are sufficiently in demand to justify their higher cost. Finished hemp twines are manufactured in four qualities--the "AA Italian" and "B American," which are made from pure hemp; and the "AB Italian" and "BC" or "BC American", which are made from hemp mixed with jute. Most of the finished hemp twine production is of the AB Italian type. Unfinished hemp twines are classified into first and second grades of "Italian" and "American" hemp construction. Hemp twines are used as mattress twines, tufting twines, broom and brush twines, for fastening springs in the manufacture of furniture and upholstery, and for certain other purposes.

Flax twines are used in the manufacture of brooms, for sewing bags and other articles, in fishlines and fish nets, and on Jacquard weaving equipment in textile mills. In the size range in which they are manufactured, from 1,140 to 2,280 feet per pound, they offer greater strength than any other twines.

Cotton twines.- In tensile strength and yardage per pound, the medium and coarser sizes of cotton twines are comparable with the finer and medium sizes of jute twines. However, finer cotton twines are not comparable with any other type since they are the only twines sold commercially which have a length of more than 2,300 feet per pound of weight. Cotton twines are manufactured in a large range of sizes in both polished and unpolished constructions and are available for a large number of uses, but are used principally for tying light packages. These twines are discussed in detail later.

18/ Specifications for jute twines are given in Simplified Practice Recommendations R-110-29 (1930) of the Bureau of Standards on "Soft Fiber (jute) Twine." Individual sizes of unpolished jute twine are designated by the yarn weight in pounds and by the number of ply, as for example, "12-pound 2-ply." The yarn weight is based on the Scotch Spindle System, and is the weight in pounds of 43,200 feet of yarn. Finished jute twines are designated by arbitrary numbers comparable to those used for finished hemp twines.

Paper twines.- An increasing amount of paper twine is being manufactured. Production totaled 31 million pounds and was valued at nearly 2 million dollars during 1937. Undoubtedly most of the paper twine manufactured is converted into articles such as woven paper bags and imitation rattan furniture. In addition, according to trade estimates, considerable quantities are used as electrical insulation twine, fleece twine, handle cord, automobile tacking strip, and seaming cord. Paper twine is used for electrical insulation because of its high dialectric resistance and because of the stiffness and resiliency it gives to the electrical product. Paper fleece twine is used for tying fleece as it is clipped from sheep, and is recommended for this purpose as any fragment which becomes mixed with the wool will be dissolved in the scouring process. Handle cord is used for handles on paper shopping bags, and seaming cord for seams in upholstery. Automobile tacking strip is not strictly a twine but a shaped, molded product and is used as its name indicates.

TRENDS IN PRODUCTION AND USE OF CORDAGE AND TWINE

Cordage and Twine Other Than Binder Twine

Exclusive of binder twine, which is considered separately owing to special factors governing its production and use, the total production of cordage and twine during 1937 was 339 million pounds, valued at 62 million dollars. This total was approximately equal to the production during the census years of 1909, 1914, and 1919; was considerably smaller than the peak production of 407 million pounds in 1929; but was considerably larger than the total of only 253 million pounds during 1931 (table 8). In general, it may be said that total production, exclusive of binder twine, has shown little or no sustained increase during the last 30 years, and that it has lagged behind in comparison with trends in the total industrial production of the country and considering increases in population.

This picture does not hold true of all types of cordage and twine as some have increased in importance while others have decreased. For instance, production of cotton cordage and twine now comprises 29 percent of the total production of cordage and twine (exclusive of binder twine) as compared with 16 percent in 1914 and in 1919. Production of cotton twine was more than twice as large during 1937 (73.3 million pounds) as in 1919 (35.3 million pounds) but was less than in 1929 (88.1 million pounds). Production of cotton cordage increased less rapidly between 1919 (17.7 million pounds) and 1937 (27.2 million pounds) but likewise was at a maximum in 1929 (28.1 million pounds) (table 9).

Other trends in the production of cordage and twine during recent years include: (1) A decline in the production of abaca' (Manila) cordage from the levels prevailing during the World War period and during 1925-29, (2) an almost complete disappearance of jute cordage from use since 1929, and (3) some increase in the production of hard-fiber twines (other than binder twine) during the last few years.

Table 8.- Quantity and value of cordage and twine exclusive of binder twine and of cotton cordage and twine manufactured in the United States during designated years, 1899-1937.

Year	Quantity			Value		
	Cordage and twine	Cotton cordage and twine	Percentage made of cotton	Cordage and twine	Cotton cordage and twine	Percentage made of cotton
	Million pounds	Million pounds	Percent	Million pounds	Million pounds	Percent
1899	190 1/	22 1/	--	19 1/	3 1/	--
1909	336	58	17	53	11	33
1914	322	50	16	39	10	26
1919	336	53	16	94	27	29
1921	233	--	--	47	--	--
1923	358	63	18	74	26	35
1925	340	76	22	79	29	37
1927	373	93	25	80	29	36
1929	407	116	29	90	38	42
1931	254	69	27	40	14	35
1933	262	87	33	38	18	47
1935	279	76	27	46	21	46
1937	339	100	29	62	26	42

1/ Does not include cordage produced in cotton goods industry.

Compiled from Census of Manufactures.

As shown in figure 1, fluctuations from year to year in production of cordage and twine accompany similar fluctuations in the output of all manufacturing industries. If the index of industrial production is high, as it was in 1937, production of cordage and twine also is large. This is not unusual in view of the utilization of cordage and twine in a wide range of industrial activities.

Production trends differ from consumption trends as part of the production is exported and part of the consumption is imported from foreign sources. Although more cordage and twine other than binder twine was exported than was imported before 1927, the opposite has been true during the last few years. Imports rose steadily after 1916, increasing from 1.5 million pounds during that year to 17.9 million pounds in 1929. Since 1929 they have ranged between 7.6 (1938) and 13.4 (1935) million pounds per year. Nearly all of the cordage and twine imported is of hard fiber, but small quantities of imports are made of jute, flax, and hemp. In addition, there are a few imports of cotton cordage and twine, particularly of seine twine, but these are not shown separately by foreign commerce statistics.

Table 9.- Production of cordage and twine in the United States during census years, 1899 - 1937

Item	1899	1909	1914	1919	1921	1923	1925	1927	1929	1931	1933	1935	1937
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
Cordage 1/ :													
Abaca (Manila hemp)	83.3	125.8	104.9	130.4	71.8	92.3	101.0	105.6	114.5	62.6	63.3	75.4	88.1
Sisal and Henequen	46.9	64.2	53.4	42.6	41.5	66.1	48.3	43.7	43.5	30.0	20.2	2/ 12.3	2/ 16.5
Cotton	3/ 1.6	24.4	18.8	17.7	17.3	24.5	25.9	27.4	28.1	21.0	27.1	22.8	27.2
Jute	10.0	27.7	4/	29.7	4/	4/	4/	12.3	12.2	4/	4/	.3	4/
Other	---	4.5	26.9	11.0	8.6	34.7	58.1	43.7	5.8	3.1	1.0	.1	.2
Total cordage	141.8	246.6	204.0	231.4	139.2	217.6	233.3	232.7	204.1	116.7	111.6	110.9	132.0
Twine :													
Hard fiber binder	5/ 165.6	5/189.2	5/302.3	5/229.5	5/236.4	295.4	290.0	227.6	225.9	186.4	199.7	166.2	157.8
Other hard fiber 1/	4/	4/	4/	4/	4/	4/	4/	4/	13.2	13.1	27.3	47.4	52.9
Cotton 6/	20.3	34.1	31.2	35.3	4/	38.9	49.9	66.0	68.1	47.6	60.2	53.4	73.3
Jute	1.7	35.5	55.3	52.4	4/	4/	4/	38.7	68.8	59.0	46.9	7/ 42.8	7/ 40.7
Flax 6/	3.8	3.0	4.0	8/	4/	4/	4/	.8	1.0	1.1	4.0	1.6	2.1
Hemp	9.1	8.0	9.3	8.0	4/	4/	4/	6.1	4.9	4.3	---	9/ 3.1	9/ 3.3
Other	13.0	8.9	18.7	8.5	93.8	101.1	56.6	28.6	26.9	12.1	12.0	10/ 19.5	10/ 34.3
Total twine	213.5	278.7	420.8	333.7	330.2	435.4	396.5	367.8	428.8	323.6	350.1	334.0	364.4
Total twine exclusive of binder twine	47.9	89.5	118.5	104.2	93.8	140.0	106.5	140.2	202.9	137.2	150.4	167.8	206.6
Total production, cotton twine and cordage	3/ 21.9	58.5	50.0	53.0	11/	63.4	75.8	93.4	116.2	68.6	87.3	76.2	100.5
Total production, twine and cordage other than binder twine	189.7	336.1	322.5	335.6	233.0	357.6	339.8	372.9	407.0	253.9	262.0	278.7	338.7
Total production, twine and cordage	355.3	525.3	624.8	565.1	469.4	653.0	629.8	600.5	632.9	440.3	461.7	444.9	496.4

1/ Quantities of other hard fiber twines probably included with cordage prior to 1935.
2/ Includes following quantities of "all other hard fibers, sisal specialties, and abaca mixed with other hard fibers" : 1935, 5.4 million pounds; 1937, 8.6 million pounds.
3/ Does not include cotton cordage produced in cotton goods industry.
4/ Not reported separately.
5/ Does not include prison production.
6/ Includes quantities listed as fishline after 1925.
7/ Includes mixed jute and istle (or other semi-soft fiber.)
8/ 84,415 pounds.
9/ Includes mixed flax and hemp and jute twines.
10/ Includes 13 million pounds of paper twine in 1935, 31 million in 1937.
11/ No data.

Compiled from Census of Manufactures.

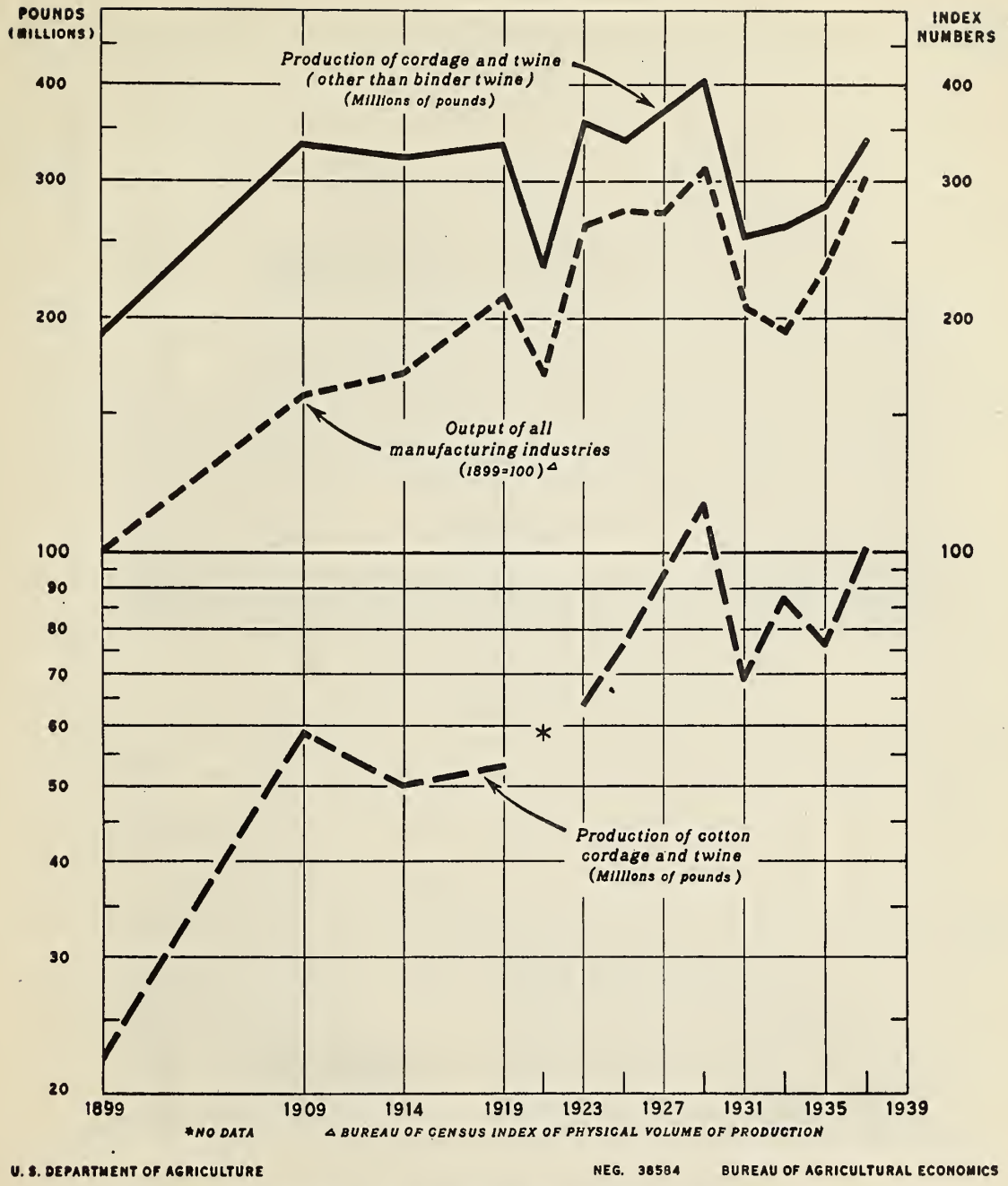

FIGURE 1.- TRENDS IN PRODUCTION OF CORDAGE AND TWINE, COTTON CORDAGE AND TWINE, AND IN OUTPUT OF ALL MANUFACTURING INDUSTRIES IN THE UNITED STATES DURING CENSUS YEARS, 1899-1937

Production of cordage and twine varies considerably from year to year in accordance with factors such as the state of industrial activity. Although production of cotton cordage and twine increased considerably during the last 30 years, total production of cordage and twine (except binder twine) remained at a stationary level.

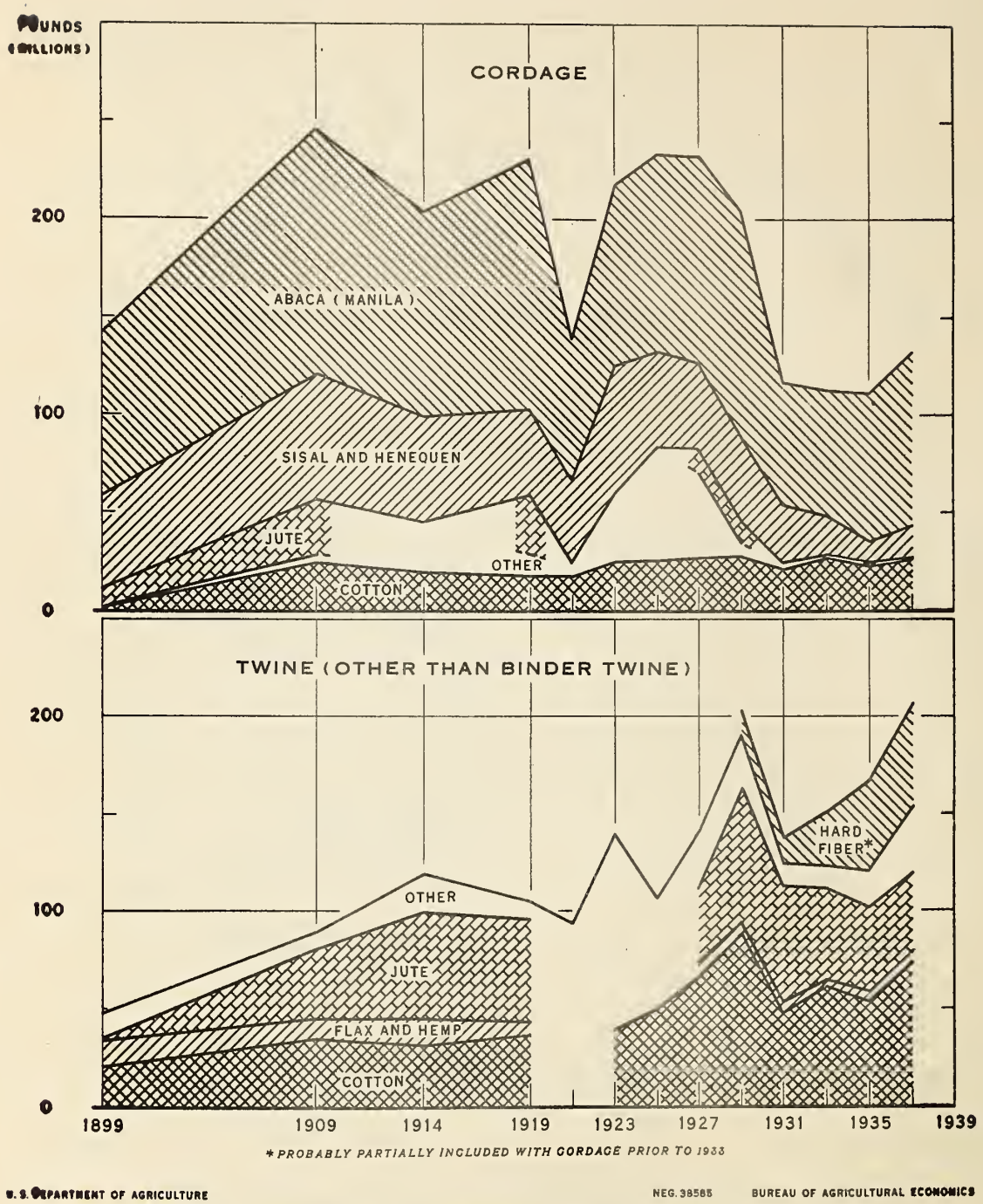

FIGURE 2.- PRODUCTION OF DESIGNATED TYPES OF CORDAGE AND TWINE IN THE UNITED STATES DURING CENSUS YEARS, 1899-1937

Although production of twine has shown an upward trend during the last 30 years, production of cordage has declined. Cotton twine production increased from 1914 to 1929 but has failed since to equal the record of the latter year. Cotton cordage production has followed a more stable, level trend but likewise reached a maximum in 1929.

Exports of twine and cordage other than binder twine increased from about 10 million pounds a year before the World War to a maximum of more than 20 million pounds in 1919. They remained above the pre-war level during the 1923-29 period, but since 1931 have ranged between only 3.8 million pounds (1932) and 6.6 million pounds (1937) a year.[19] Exports of cotton cordage and twine varied during the same period between 2.2 million pounds (1935) and 3.0 million pounds (1937) a year.

Total exports of cordage and twine other than binder twine have never totaled more than 4 percent as much nor total imports more than 3 percent as much as the total production. Consequently, trends in the consumption of cordage and twine have differed only slightly or not at all from trends in the production of these products. However, imports of hard-fiber cordage and twine other than binder twine probably totaled about 10 percent as much as the domestic production of these products during 1939. Cotton twine and cordage exports equalled only 3 percent as much as the domestic production in 1937.

Binder Twine

Because of the unique use of binder twine in harvesting certain agricultural crops, trends in the production and consumption of this product differ considerably from trends in the production of cordage and twine other than binder twine. Production of binder twine has been characterized by a continued downward trend for more than two decades and the total of 158 million pounds which was produced by both private and prison industries in 1937 was only slightly more than half the 302 million pounds manufactured by private industry alone in the peak year of 1914 (table 10). Despite this decline, binder twine comprised 32 percent of the total production of cordage and twine during 1937.

The decline in domestic manufacture of binder twine is explained in part by the disappearance of a substantial export market in binder twine and by the marked increase in imports from foreign countries. Exports of binder twine declined from 109 million pounds in 1914 to less than 10 million pounds annually during the last 6 years. Imports of binder twine increased from 11 million pounds in 1925 to 75 million pounds in 1936, 58 million pounds during 1937, and 50 million pounds in 1939. Principal countries from which binder twine is imported at present are Mexico, Netherlands, Belgium, Canada, Cuba, and Great Britain; and the principal countries to which it now is exported are Argentina and the Union of South Africa.

19/ Import quantities quoted refer to combined imports for consumption of (1) hard-fiber cordage and twine other than binder twine; (2) flax, hemp, and ramie thread, twine and cordage; and (3) jute cordage, twine, and twist. Export quantities quoted refer to total domestic exports of (1) cordage, except binder twine, except of cotton or jute; (2) cotton twine and cordage; (3) and jute yarn, cordage, and twine.

Table 10.- Binder twine production, imports, exports, and quantity made available for consumption, United States, census years, 1899-1937.

Year	Production	Imports for consumption 1/	Domestic exports 1/	Made available for consumption 2/
	Million pounds	Million pounds	Million pounds	Million pounds
1899	166	2	3/	4/
1909	189	14	3/	4/
1914	302	7	109	200 5/
1919	230	13	69	174
1921	236	5	59	182
1923	295 6/	13	74	234
1925	290 6/	11	54	247
1927	228 6/	16	19	225
1929	226 6/	19	17	228
1931	186 6/	23	10	199
1933	200 6/	48	6	242
1935	166 6/	56	6	216
1937	158 6/	58	5	211

1/ For fiscal years prior to 1919.
2/ Production plus imports minus exports.
3/ Not reported separately until 1910.
4/ No data.
5/ Production for calendar year 1914 plus imports and minus exports for fiscal year ended June 30, 1914.
6/ Includes following amounts manufactured in prisons: (in millions of pounds) 1923, 55.6; 1925, 56.3; 1927, 57.8; 1929, 47.3; 1931, 52.2; 1933, 57.1; 1935, 57.3; 1937, 42.8.

Compiled from Census of Manufactures and from Foreign Commerce and Navigation of the United States.

Another factor contributing to the downward trend in binder twine production has been a decline in the domestic demand. This resulted primarily from the decreasing use of binders attendant upon the increasing use of combines (harvester-threshers). It is estimated that only 60 percent of the total acreage of small grains in the United States is now harvested with binders as compared with 85 percent in 1920. At the same time, total acreage of these crops has decreased. As a result of these changes, annual consumption of binder twine is estimated to have declined from about 250 million pounds in the period 1918-20 to about 175 million pounds at present.

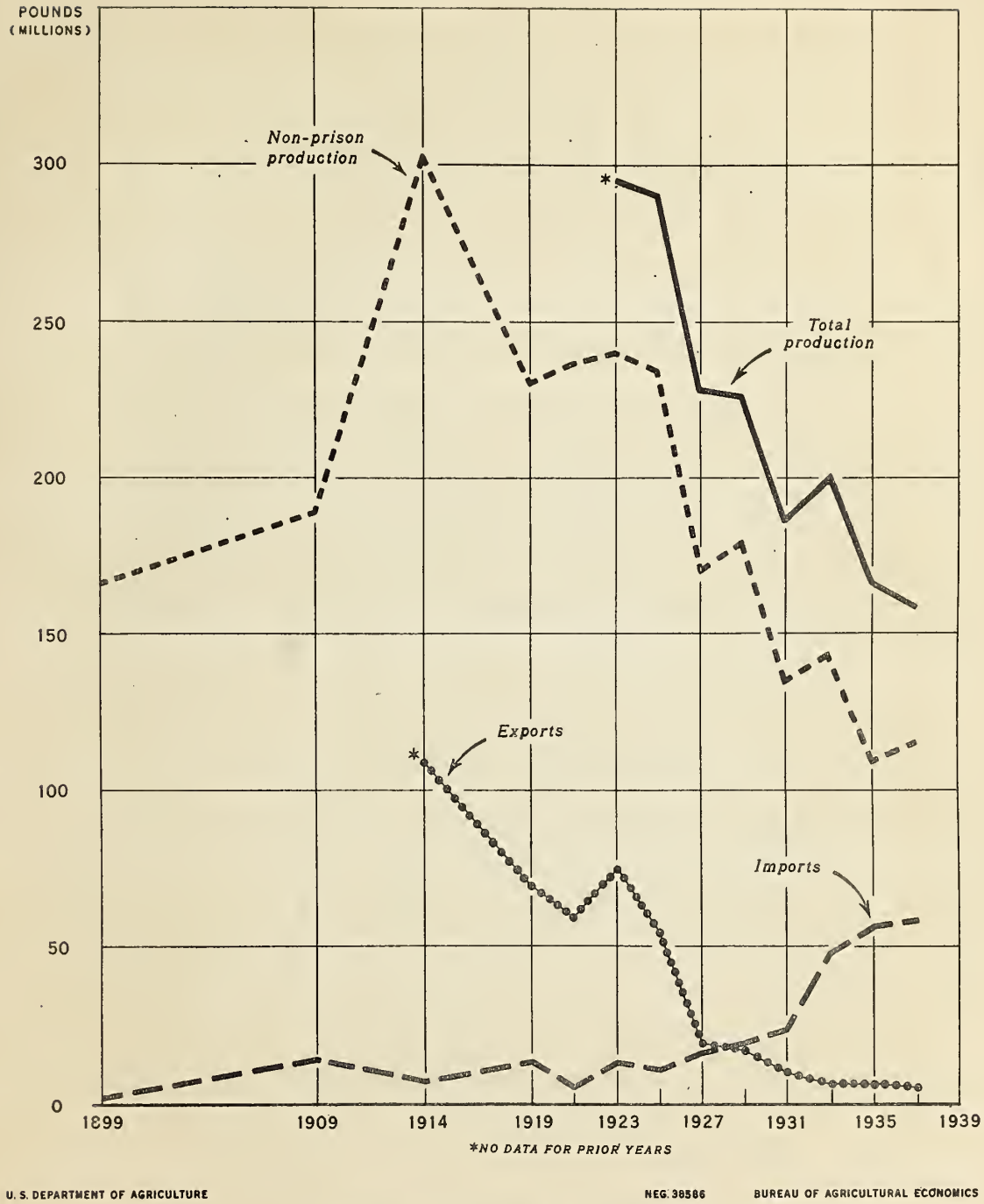

FIGURE 3.- PRODUCTION, IMPORTS, AND EXPORTS OF BINDER TWINE, UNITED STATES, DURING CENSUS YEARS, 1899-1937

Production of binder twine in the United States has declined tremendously since 1914 as the result of (1) the increasing use of combines (harvester-threshers) in place of binders, (2) the decline in the acreage of small grain crops, (3) loss of export markets, and (4) increased imports.

Aside from the factors noted, the amount of binder twine required annually depends upon the amount of straw, including weeds, produced per acre. This in turn is dependent upon growing conditions and other factors. Consumption is highly seasonal, occurring at harvest time, and large stocks are required for sudden demands. If crop failures occur, large carry-overs are likely and production during the ensuing year may be curtailed. It is not unusual for binder-twine manufacturers to carry over as much as half their total production into the following year.

COTTON TWINE AND CORDAGE AND FACTORS INFLUENCING THEIR USE

In the foregoing section of this report a background of facts has been presented concerning the materials used and the products manufactured by the cordage and twine industry. In this and the following section a more detailed discussion of the utilization of cotton in cordage and twine may be found. Types of cotton twines and cordage manufactured are surveyed and factors influencing their use are discussed. Information also is presented on quantities and grades of cotton used in cordage and twine, and on trends in the consumption of cotton in this use.

Of the total of 100.5 million pounds of cotton twine and cordage manufactured in 1937, 73.3 million pounds were twine and 27.2 million pounds were cordage. Cotton twine has comprised between 32 percent and 40 percent of the total production of twine other than binder twine during the last 4 biennial census years; cotton cordage between 18 percent and 24 percent of the total production of cordage.

In comparison with other twines, cotton twines are used when qualities such as flexibility, softness, light weight, and appearance are of major importance. They are manufactured in a large number of constructions, qualities, and sizes for a variety of uses. Although there is no definite, standardized classification of these twines, they may be divided on the basis of their principal uses, into three main groups as follows: (1) Twines generally used for tying packages including "wrapping," "sail," and "polished" twines; (2) twines used principally for fishing purposes, including "seine" twines, "trot-lines," "staging" twines, and other fishing lines; and (3) twines used for sewing and other purposes.

Of the three groups, twines used for tying packages are of greatest importance, and on the basis of reports from manufacturers are estimated to comprise nearly two-thirds of the total production. Sewing and other twines make up an additional 23 percent of the total, approximately, and fishing twines comprise the remainder of 13 percent (table 11).

Table 11.- Estimated production 1/ of cotton twines, by kinds, in the United States, 1935-37.

Kind of twine	1935	1936	1937
	Million pounds	Million pounds	Million pounds
Tying (Wrapping, sail, and polished)			
Unpolished (59.7 percent)	31.9	40.8	43.8
Polished (5.5 percent)	2.9	3.7	4.0
Total (65.2 percent)	34.8	44.5	47.8
Fishing (Seine, trot, staging, and other fishing) (13.0 percent)	6.9	8.9	9.5
Sewing and other (21.8 percent)	11.7	14.9	16.0
Total (100 percent)	53.4	68.3	73.3

1/ Estimated on basis of reports from manufacturers representing 69 percent of production in 1935, 65 percent in 1937. Total production data for 1935 and 1937 are from the Census of Manufactures, but are estimated for 1936. Production of each item is total production multiplied by estimated percentage shown in parenthesis. Percentages are average proportions for 3 years as indicated by manufacturers' reports, the proportions varying 1 percent or less from year to year.

Cotton Twines for Tying Packages

In the first group, composed of twines used for tying purposes, the bulk of the production is of wrapping twines. There are no standardized specifications for wrapping twines, but they are unpolished and ordinarily range in size from a 3-ply construction, with a length of about 6,000 feet to the pound, to a 30-ply construction, with a length of about 670 feet to the pound. The fine 3- and 4-ply sizes, which are beyond the range of the finest noncotton twines, are reported to be most heavily used, followed by the 16-ply size which is used extensively for packages of medium size. Some cotton wrapping twines are manufactured entirely from lint cotton but others are made either partly or entirely from cotton waste, chiefly card strips and comber noils. Production of lower grades of twine is reported to have increased considerably during recent years at the expense of higher grades, owing to changing demands from purchasers. As a general rule, the higher grades for use east of the Rockies are made of 8's yarn spun from lint cotton and the cheaper grades are made from 6's yarn containing a percentage of waste. Wrapping twines used on the Pacific coast are made usually from 6.50s or 3.25s yarn spun from lint cotton.

Cotton wrapping twines are available in various colors and are put up in balls, cones, tubes, and cut lengths. Federal specifications for these twines, which may be taken as approximately representative of twines in commercial use, are shown in table 12.

Table 12.- Construction, length per pound, and breaking strength of unpolished cotton wrapping twine.

Ply	Minimum average length per pound	Minimum average breaking strength
	Feet	Pounds
2	9,000	3
3	6,000	5-1/2
4	4,500	8
5	3,600	10
6	3,000	12
8	2,250	16
10	1,800	20
14	1,290	28
16	1.125	32
24	750	48

From Federal Standard Stock Catalog, TT-871, Sept. 16, 1930; Section IV (part 5); Federal specifications for twine, cotton, wrapping.

Other types of unpolished cotton twines used for tying packages include "sail," "Sea Island," "butchers'," and other twines. Sail twines are identical with the larger sizes of wrapping twines and are so called because they once were used extensively for sewing sails. The term still is applied to twines used for hand sewing, but it also is applied by manufacturers to twines used mainly for tying packages. Sea Island twine is a high-quality twine of cabled construction, used almost entirely in the drug trade. It is so named because it originally was made from Sea Island cotton. Butchers' or "packers'" twine is representative of a group of twines which have trade names to indicate the particular use for which they were manufactured.

Polished cotton twines.- In addition to the twines discussed above, a substantial quantity of polished cotton twine is used mainly for tying purposes. Polished cotton twines are similar to wrapping twines but have been specially treated with a solution of starch, wax, and other materials to obtain greater smoothness and strength and a more attractive appearance. According to standard specifications,[20] there are two types, "special" and "standard." Special twines are made from 8's yarn twisted in the required number of plies for the size to be made and standard twines are made similarly from 2's yarn. Polished cotton twines in general use have a length per unit of weight ranging from 250 to 4,820 feet to the pound and corresponding breaking strengths ranging from 170 to 11 pounds (table 13).

20/ Bureau of Standards, Simplified Practice Recommendation R-124-31.

Table 13.- Construction, length per pound, and breaking strength of polished cotton twines.

Twine number	Length per pound	Special		Standard	
		8's yarn	Breaking strength	2's yarn	Breaking strength
	Feet	Ply	Pounds	Ply	Pounds
5 1/	4,820	4	11		
9 1/	3,150	6	16		
12 1/	2,325	8	23		
15 1/	1,900	10	28		
18	1,575	12	34	3	29
24	1,175	16	41	4	35
36	950	20	57	5	48
48	750	24	75	6	56
60	600	30	85	7	75
4 1/2	475	40	110	10	95
6	375	48	135	12	120
7	300	60	155	15	150
8	250	72	170	18	160

1/ Not manufactured in standard (2's yarn) construction.

All figures approximate. Compiled from U. S. Department of Commerce, Bureau of Standards, Simplified Practice Recommendation R-124-31 for polished cotton twine, and from trade catalogs.

Cheaper grades of polished cotton twine, which do not conform with the specifications given in table 13 have been placed upon the market during the last few years. In general, these twines also are of 8's and 2's yarn construction, but as they are manufactured from cotton of lower quality they are inferior in strength to the standard types.

Factors influencing use of cotton twine for tying purposes.- Cotton twines find their principal use in the packaging field as a material for tying the small and medium-sized packages of retail trade. Larger packages, such as those generally used for movements of merchandise from factory or wholesaler to retailer, are tied usually with jute or hard-fiber twines if twines are used at all. There is no exact line of demarcation between use of cotton and other twines, but rather a zone in which both types are in competition.

Even in the medium- and small-package field, cotton twine is used on only a fraction of the total packages. An increasing proportion of packages consists of boxes or other containers requiring no twine. Paper bags used by grocers and dry-goods stores are an example of this type. In addition, there is an increasing use of gummed-paper tape for fastening packages in place of twine.

Cotton-twine sales have been more seriously influenced by competition from gummed-paper tape during the last few years than by competition from noncotton twines. A widespread tendency to substitute this material for cotton twines has been noted in certain types of retail stores like the limited-price variety stores, particularly where large numbers of packages of identical size are wrapped at a single place.

Gummed-paper tape was developed about 35 years ago, and its first general use occurred in connection with corrugated and fiber shipping containers. Its use for parcel-sealing purposes has been a later and, judging from estimates in 1933 that this use required only 10 percent of all sealing tapes,[21] a less important development. Gummed-paper sealing tapes now generally in use for binding medium and small packages are made of a 35-pound Kraft paper which has been coated with an adhesive compound weighing approximately 33 percent of the finished product. This tape is sold in 500-foot and 800-foot rolls and in widths of three-fourths of an inch, 1, 1-1/4, and 1-1/2 inches.[22]

One of the advantages claimed for gummed-paper tape is that a much smaller amount of tape is required for binding a package than if twine is used. The amount used of each varies with the package, but as a general rule it is estimated that from 3 to 8 times more cotton twine than gummed-paper tape is required per package. However, gummed tape generally costs from 1 to 3 times as much per foot as medium and fine sizes of cotton wrapping twine.

Another advantage claimed for gummed-paper tape is that it speeds up the wrapping process and thus saves the time both of the clerk and of the waiting customer. Other advantages are that it seals packages, affording safety against pilfering, and gives the package a smooth surface. The fact that advertising legends may be printed on the tape has the effect of reducing the expense chargeable to wrapping costs.

One of the chief disadvantages of gummed-paper tape is that machines are required to dispense it and that these machines sometimes require a considerable initial investment, particularly if packages are wrapped at a number of stations in an establishment. The simplest machines used for this purpose cost $3 or $4, while lever-operated machines suitable for dry-goods stores or groceries range from $12 to $40 in cost. Other disadvantages are that sometimes the adhesive quality of the tape is not altogether satisfactory and that the dispensing machines occasionally require repair. If the gummed-tape seal on a package becomes loose or broken, it cannot be replaced so readily as a loosened twine wrapping. Twine enables a package to be grasped and carried more easily.

21/ Letter to Agricultural Adjustment Administration from Gummed Industries Association.

22/ National Bureau of Standards, Simplified Practice Recommendation R-114-30; Tape; Sealing, No. 1 Kraft paper.

There is no doubt that gummed-paper tape is now being used for a larger number of packaging purposes formerly requiring cotton and other kinds of twine, and that this replacement tendency is continuing. How far it will continue is not easily surmised. Without doubt both twines and gummed tape sooner or later will find positions in the market for wrapping materials in which each has clearly recognized advantages, but the extent to which each will be used is as yet uncertain.

Competition from other twines.- Cotton twines also compete with other types of twine as a material for tying packages. This competition is intense and has resulted in considerable shifts in kinds of twine used. Present competitive relationships between twines, on the basis of the footage of designated strength that is obtainable per unit of cost are shown in figure 4. As indicated in the upper left corner, the finest sizes of cotton twines yield a greater footage per unit of cost than any other type and are the only twines for sale commercially with breaking strengths of less than 20 pounds. It is noteworthy that the most extensively used sizes of cotton wrapping twines fall within this group. In the medium-strength range, cotton twines of intermediate and coarser sizes encounter competition from twines made of jute, hemp, and flax. Jute twines here compete on fairly even price terms with cotton twines but hemp and flax twines of equal tensile strength are available only at a higher cost.

The coarsest sizes of cotton twines also are comparable in strength with the finest sizes of hard-fiber twines, some types of which offer a considerably greater footage per unit of cost. For requirements demanding a breaking strength of more than about 160 pounds, only hard fiber and jute twines, and to a small extent hemp twines, are used. Although certain sizes of cotton seine twines are manufactured with breaking strengths ranging up to 600 pounds, they are too expensive for ordinary wrapping purposes.

If cotton twines rise or fall in price as compared with other twines, their competitive situation improves or deteriorates as the case may be. As indicated in figure 5, the price of cotton wrapping twine showed a downward trend from 1927 to 1932, both absolutely and relative to the price of twines made of other fibers. Following an abrupt rise in 1933, it remained at a comparatively stable level until 1937 when it again declined. During recent months the price of cotton twines has again increased, but this increase has been accompanied by similar changes in the prices of jute and hard-fiber twines.

Although prices of various twines have been discussed on the basis of breaking strength, it should be remembered that breaking strength is an important factor in twine competition only insofar as the requirements of particular situations dictate. Cotton twines sometimes are preferred to twines of higher breaking strength, as they are easier to manipulate or to break. They are preferred sometimes too, because of their comparative resistance to friction or breaking when the twine is knotted or passed over an edge or corner. This last factor sometimes is referred to as "working strength."

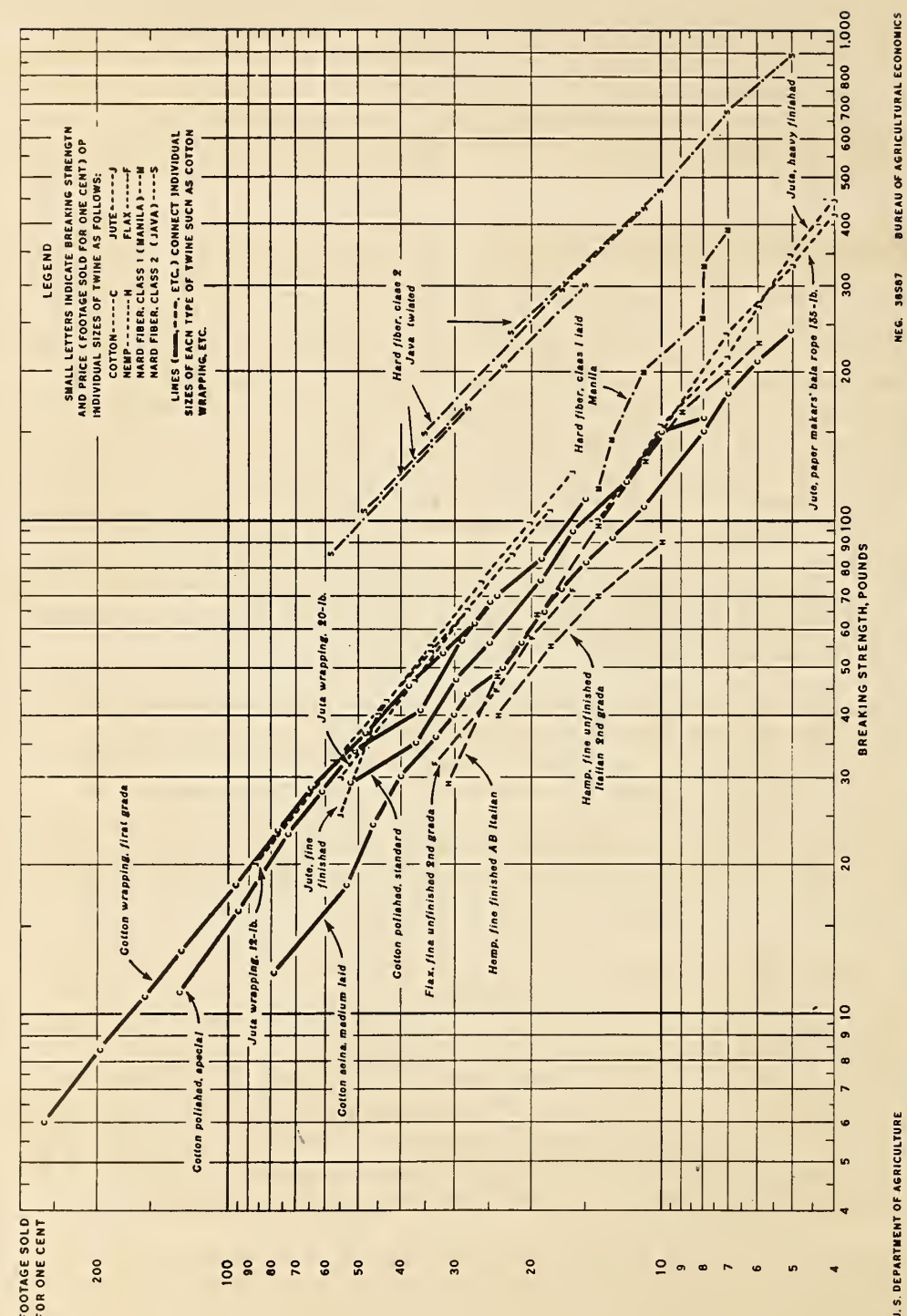

FIGURE 4.- PRICES (FOOTAGE SOLD FOR ONE CENT)1/ OF DESIGNATED TWINES OF EQUAL BREAKING STRENGTHS, JULY 1940

This chart shows the footage of each twine, of the breaking strength shown on the horizontal scale, which was being sold for one cent in July 1940. As is indicated, fine, low-strength cotton twines offered the greatest footage per unit of cost; and medium and coarse cotton twines were sold for about the same price (per foot) as jute twines of equal strength.

1/ Based on manufacturers' wholesale quotations.

FIGURE 5.- AVERAGE WHOLESALE PRICES PER POUND OF CERTAIN TYPES OF TWINE AND CORDAGE, BY MONTHS, 1926-40

Prices of cotton twines and cordage fluctuate more widely than prices of other types. At present they are intermediate between the low and high extremes of the last eight years. Since prices are given for certain types only and on a weight basis, they indicate trends in prices rather than competitive relationships during any given period.

Other factors of importance in determining the suitability of a twine are its elasticity, diameter, appearance, and touch. Cotton twine is more elastic than other twines and may be at an advantage or disadvantage if it is to be subjected to a varied stress. If the diameter is too small, there may be a tendency to cut fingers or the package. On the other hand, too great a bulk may be a disadvantage.

Appearance of a twine, its natural or artificial color, and its stainlessness, also are of considerable importance if the twine is to be used for retail packages. The natural white color of high-quality cotton twine often gives it an advantage in such uses. Touch, or whether the twine is soft, pliable, stiff, or hard, is still another factor. Cotton's softness is an advantage when the twine is manipulated by hand but it is a disadvantage if a comparatively stiff, non-kinking twine is desired. The polishing process overcomes this disadvantage to some extent by increasing the rigidity and smoothness of the twine, but it also results in a decrease in softness.

In summary, the market for all kinds of tying twines and gummed tape has decreased owing to an increased use of containers like bags, cartons, and envelopes which require no fastening material. The share of this market secured by cotton twine is dependent upon competitive factors referred to above, and evidence indicates that although cotton twine has more than held its own in relation to other kinds of twine, it has lost part of its market to gummed tape. As cotton wrapping twines are used largely in retail business, it is to be expected that their consumption would vary directly with fluctuations in the amount of business, but little quantitative proof is available to support this assumption. Over short periods of time, cotton-twine sales also are influenced to some extent by buyers' policies of timing their purchases in an effort to take advantage of fluctuations in the cotton market.

Cotton Twines for Fishing

A second group of cotton twines includes twines used primarily for fishing purposes either in the manufacture and repair of fish nets or as fishlines. These twines are known as seine twines, trotlines, staging twines, fishlines, and others, and are estimated to comprise approximately 13 percent (9.5 million pounds in 1937) of the total production of cotton twines. With the exception of some fishlines which are braided, all twines in this group are characterized by having a cabled construction, being made up of three or more strands, each of which consists in turn of a number of yarns twisted together.

Of the total production of cotton twines used mainly for fishing, more than 85 percent are seine twines. Seine twines are divided into soft, medium, hard, and extra hard-laid constructions, according to the degree of twist imparted in the forming and cabling operations, and are made in various sizes which are designated by the number of individual yarns or threads of which each consists. In length per unit of weight, sizes range from approximately 3,460 feet

per pound to 75 feet per pound and less, but more commonly used sizes range between 1,700 and 300 feet per pound. All are of 3-strand construction except soft-laid seine twines of size 20 and larger which are composed of 4 strands.

According to manufacturers, most seine twines are used in the manufacture or repair of netting, the medium-laid constructions being preferred for this purpose. However, soft-laid seine twines are used for hanging nets when drying and for tying nets together, and hard or extra hard-laid seine twines are used as fishing lines, being too rigid to knot without difficulty. These uses are estimated to require about 90 percent of the production of seine twines, the remainder going into such nonfishing uses as laundry nets, tennis nets, and mason's chalk lines.

Table 14.- Approximate length per pound and breaking strength of cotton twines used for fishing. 1/

Kind	Length per pound		Breaking strength	
	Finest size	Coarsest size	Finest size	Coarsest size
	Feet	Feet	Pounds	Pounds
Seine twine:				
Soft-laid (6 to 240 thread)	3,460	85	12	486
Medium-laid (6 to 240 thread)	3,300	65	12	600
Hard-laid (6 to 240 thread)	2,900	75	12	484
Extra hard-laid (6 to 120 thread)	2,900	150	12	240
Meter cord (60 to 260 thread)	260	55	150	610
Trotline (24 to 153 thread)	510	60	60	350
Staging twine (9 to 33 thread)	1,380	345	23	84

1/ Specifications shown are for finest and coarsest sizes of each kind of twine, construction of which is indicated by data in parentheses. Specifications are compiled from trade literature but are not necessarily representative of twines produced by all manufacturers.

Other cotton twines used primarily for fishing include trotline, staging, meter cord, and fishline. Trotline is the "leader" line which is strung out during fishing operations, and staging twine is the small hook line suspended at intervals from it. Large sizes of seine twine that are used chiefly for hanging nets are sometimes called meter cord, particularly in the Great Lakes Region. Cotton fishlines consist partly of cabled twines that are identical with seine twines and partly of braided twines, the braided construction sometimes being preferred because of its resistance to tangling and untwisting.

Factors influencing consumption of cotton fishing twines.- As compared with other fibers, cotton occupies a dominant position in meeting the needs of the fishing industry. Nettings made of cotton twines are estimated to comprise about 72 percent by weight of all netting used in the United States as compared with 8 percent composed of linen nettings and 20 percent of manila netting.[23/] With the exception of a small quantity of hemp halibut line and small quantities in weight of silk and linen fishlines for noncommercial fishing, cotton twines are the only fishlines used.

Shifts from fishing tackle made of one fiber to tackle made of another, as a result of price changes, are reported to be negligible, since each kind of tackle has well-defined uses with requirements which do not permit ready substitution. However, it is likely that price fluctuations are of some importance in determining the quantity of tackle that can be sold and it is therefore noteworthy that these prices have shown considerable variation in recent years. For instance, the price of medium-laid, 9-thread seine twine fell from a peak of about 59 cents per pound during 1928 to a minimum of 31 cents in 1933, and was quoted at 38 cents per pound in July 1940.

Of much greater importance than price changes are fluctuations in the volume and profitability of fishing activity. When fishing is unprofitable, old nets and other tackle, which in better times would be replaced, are kept in use by dint of much repairing and with some loss of efficiency in fishing operations. Furthermore, fishing is carried on with fewer nets.

Sewing and Other Cotton Twines

A third group of twines, comprising about one-fifth of the total production of cotton twine, includes twines not used either for tying or fishing purposes. More than half of the production of this group consists of sewing twines, which are used for sewing bags and other articles requiring a yarn or cord that is heavier than is ordinarily implied by the term thread. These twines often are identical with certain sizes of wrapping twines, which sometimes are advertised as being suitable for sewing purposes.

Other twines included in this group are used for a variety of purposes, as indicated by their names. "Hop" twines and "pea" twines, which are used in agriculture to support growing vines, are indicative of one type of use, and "tobacco" twines, that are used for making draw strings for small sacks of tobacco and for tying leaf tobacco, are indicative of another. Other products include "broom" twines that are employed in the manufacture of brooms; "top" twines

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23/ Estimated on basis of production, imports, and exports figures given in table 1. Nets and Netting and Other Fishing Gear, Report of U. S. Tariff Commission to the United States Senate, Washington, 1937. (Report No. 117--Second Series.)

for spinning tops; cabled "kite" twines for flying kites; "webbing cord" used in the manufacture of upholstery; and "mattress tufting cord," for use in the manufacture of mattresses, to mention a few.

Although twines included in this group possess the characteristics required for their particular uses, they usually are identical with certain types of tying twines, and their use is influenced by similar technological and price comparisons with other kinds of twine. In addition, their use is controlled by the requirements and conditions prevailing in each use.

Cotton Cordage

In comparison with other cordage, cotton cordage finds wide use for requirements where tensile strength is secondary to such qualities as flexibility, softness, and appearance. Production of cotton cordage in 1937 was second only to production of abaca' cordage in quantity and value, and during the last 3 biennial census years has comprised between 20 percent and 25 percent of the total production of all types of cordage.

Classified according to construction, cotton cordage is of two types, braided and twisted. On the basis of reports from 27 manufacturers, representing nearly one-third of the production, it is estimated that about 60 percent of the total production is braided and about 40 percent is twisted (table 15).

Table 15.- Estimated production of cotton cordage by kinds in the United States, 1935-37. 1/

Kind	1935	1936	1937
	Million pounds	Million pounds	Million pounds
Braided cordage (60 percent)	13.7	16.0	16.3
Twisted cordage (40 percent)	9.1	10.6	10.9
Total	22.8	26.6	27.2

1/ Estimated on the basis of reports from manufacturers representing 29 percent of production in 1935, 32 percent in 1937. Total production data for 1935 and 1937 are from the Census of Manufactures but are estimated for 1936. Production of each item is total multiplied by estimated percentage shown in parentheses. Percentages are average proportions for 3 years as indicated by manufacturers' reports, the proportion varying 1 percent or less from year to year.

Braided cotton cordage ordinarily is made in sizes ranging from three-sixteenths of an inch to one-half inch in diameter and these sizes are designated as number 6, number 16, and so forth, according to the number of thirty-seconds of an inch in the diameter

measurement. Most extensive use of braided cordage is as clothesline and as windowsash cord but substantial quantities also are used as Venetian-blind cord, trolley cord, flag halyards, bell cords, and for other varied requirements. Most extensively used sizes are numbers 6, 7, and 8, numbers 6 and 7 being preferred for clothesline and numbers 7 and 8 as sash cord. Most of the braided cotton cordage is glazed or polished to increase smoothness and durability. Several grades are manufactured, ranging from constructions composed of rovings made of cotton waste which are braided about a center "loaded" with clay or other foreign materials to constructions made entirely from lint cotton yarns. Federal specifications for braided sash cord, which are considered to be applicable to the better commercial grades of this product are shown in table 16. Similar data for twisted cotton rope also are shown.

Table 16.- Diameter length per pound, and breaking strength of cotton cordage. 1/

Size	Braided sash cord			Rope		
	Diameter	Length per pound (minimum)	Breaking strength (minimum)	Diameter (normal)	Length per pound (minimum)	Breaking strength (minimum)
	Inches	Feet	Pounds	Inches	Feet	Pounds
6	6/32	66	225	1/8	200	120
7	7/32	51	272	3/16	90	250
8	8/32	40	328	1/4	52	420
10	10/32	27	440	3/8	23.5	890
12	12/32	19.5	560	1/2	13.5	1,450
				3/4	6	3,100
				1	3.5	5,100

1/ Federal specifications as compiled from Federal Standard Stock Catalogue, Section T-C 571; T-R 571.

In comparison with braided cordage, twisted cotton cordage or rope has greater tensile strength but is not so smooth and is more likely to suffer from abrasions. It is manufactured in sizes ranging from three-sixteenths of an inch to 1-1/4 inches or more in diameter, the sizes of less than one-half inch diameter being used most extensively. Probably half of the total production is used as plowlines on farms. It also is used in the building trades, in clotheslines and well ropes, as small ropes on ships, for awnings and Venetian blinds, for tying bundles, as transmission or driving ropes, and in other ways. Several qualities are manufactured, ranging from grades made entirely of cotton waste to constructions composed of yarns made entirely from cotton lint. It is unpolished usually.

Factors influencing use of cotton cordage.- Owing to the number of uses to which cotton cordage is applied and the lack of information concerning many of them, it is impossible to completely analyze the demand for these products. However, there is evidence of decreased use of certain products which should be recognized. For instance, the consumption of cotton sash cords has been adversely affected by the use of chains on windows and by the increased use of casement windows which do not require pulleys. The use of cotton clotheslines undoubtedly has declined with the trend towards the use of large, commercial laundries. It also is likely that use of cotton plow lines has declined with the change from horse to tractor as a means of motive power on farms. But there is no quantitative backing for any of these statements. In view of the fact that consumption of cotton cordage has been maintained, it may be concluded that increased use for certain purposes has counterbalanced losses in others. For instance, use of cotton cordage in Venetian blinds undoubtedly has increased.

Cotton cordage encounters competition from cordage made of other fibers, particularly in clothesline, but there is nothing to indicate recent substantial losses or gains as a result of this competition. Instead, fluctuations in production and consumption appear to be the result of changing demands for cordage on the part of consumers as a result of changing prices and changing business and other conditions.

UTILIZATION OF COTTON IN CORDAGE AND TWINE

Quantity and Grade of Cotton Used

According to reports received from manufacturers, the quantity of cotton used in the manufacture of cotton cordage and twine during 1937 averaged 1.18 pounds per pound of product. Although this amount was the average for the entire production, the quantity used per pound of different products varied with factors such as the quality of the product, kind of cotton used, and in regard to whether the product was polished or not. For instance, an average of 1.24 pounds was reported consumed for each pound of seine and other fishing twines manufactured but the average quantity used per pound of braided cordage, some types of which are glazed or loaded with noncotton materials, was only 1.09 pounds. For all twines combined, average consumption of cotton per pound of product was 1.19 pounds; for cordage, 1.15 pounds.

Applying the above data to total production figures, it is estimated that 118 million pounds of cotton, or the equivalent of 248,000 bales of 478 pounds net weight, were used in cordage and twine during 1937 (table 17). Most of this quantity, 182,000 bales, is estimated to have been used in twine, but nearly 66,000 bales is estimated to have been required in the manufacture of cordage. Similar estimates for previous years, assuming use of same quantity of cotton per pound of finished product, are given in table 18.

Table 17.- Production of cotton cordage and twine, percentage of production included in survey, 1/ quantity of cotton reported used per pound of product, and estimated total consumption of cotton in cordage and twine, by kind of product, United States, 1937.

Kind of product	Production		Cotton consumed	
	Percent of total included in survey	Total 2/	Average per pound of product	Total 3/
	Percent	Million pounds	Pounds	Million pounds
Tying twines (wrapping, sail, and polished)	58	47.8	1.18 4/	56.2
Fishing twines (seine, trot, staging, etc.)	81	9.5	1.24	11.8
Sewing and other twines	56	16.0	1.19	19.0
Total twine	60	73.3	1.19	87.0
Braided cordage	22	16.4	1.09	17.8
Twisted cordage	28	10.9	1.24	13.5
Total cordage	24	27.2	1.15	31.3
Total twine and cordage	50	100.5	1.18	118.3

1/ Percentage of total production for which reports were recorded from manufactures giving cotton utilization data.
2/ Production: Estimated for individual kinds. See tables 12, 16.
3/ Product of total production multiplied by average cotton consumed per pound of product.
4/ Weighed average of 1.06 pounds for polished twines, 1.18 pounds for wrapping and sail twines.

Of the total cotton reported used for cordage and twine during 1937, slightly more than one-fourth was cotton waste and slightly less than three-fourths was cotton lint. The proportion of cotton waste used in various products differed considerably, ranging from an average of only 5 percent in seine and other fishing twines to 85 percent in twisted cordage. In general, twines have a larger proportion of cotton lint than cordage, but some manufacturers reported twines which were made largely from waste and others reported cordage made entirely from cotton lint. More than 40 percent of the waste used consisted of card strips and more than 20 percent was comber waste. Other kinds of waste used extensively included fly and thread.

Table 18.- Production of cotton cordage and twine in the United States during designated years, 1899-1937, and estimated cotton equivalents. 1/

Year	Production			Cotton equivalent 1/		
	Twine	Cordage	Total	Twine	Cordage	Total
	Million pounds	Million pounds	Million pounds	1,000 bales	1,000 bales	1,000 bales
1899	20	2/ 2	2/ 22	50	2/ 4	2/ 54
1909	34	24	58	85	59	144
1914	31	19	50	78	45	123
1919	35	18	53	88	43	131
1921	--	17	--	--	42	--
1923	39	24	63	97	59	156
1925	50	26	76	124	62	186
1927	66	27	93	164	66	230
1929	88	28	116	219	67	286
1931	48	21	69	118	50	168
1933	60	27	87	149	65	214
1935	53	23	76	133	54	187
3/1936	68	27	95	170	64	234
1937	73	27	100	182	66	248

1/ Estimated cotton and cotton waste required to produce stated quantity of cordage and twine, based on loss in manufacturing of 15.8 percent for twine; 13.0 percent for cordage. Bales are of 478 pounds net weight.
2/ Does not include production of cordage in cotton goods industry.
3/ Production during 1936 estimated. Compiled from Census of Manufactures, for other years.

Most of the cotton lint used in cordage and twine was of seven-eighths of an inch or fifteen-sixteenths of an inch staple and more than half was strict low middling in grade. However, quantities of cotton in all grades between good ordinary and strict middling inclusive and of all staple lengths between thirteen-sixteenths of an inch and 1-3/32-inches, inclusive, were reported used. An analysis of cotton used in various products, showing grades and staples of cotton line and kinds of cotton waste used is given in table 19.

Trends in Consumption of Cotton in Cordage and Twine

As indicated in table 20, consumption of cotton in cordage and twine showed a continued upward trend from 1914 to 1929, except possibly during the 1919-21 period. By 1929, the quantity of cotton

Table 19.- Grades and staples of cotton and kinds of cotton waste used in the manufacture of twine and cordage products in the United States during 1937, in percentages of the total 1/

Grade or staple of cotton, or kind of cotton waste used	Cordage and twine	Twine	Cordage	Tying twine	Fishing twines	Sewing and other twines	Braided cordage	Twisted cordage
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Waste cotton:								
Card strips	11	7	22	9	2	3	7	46
Comber waste	6	6	5	8	1	2	---	4
Other	9	2	27	2	2	1	29	35
Total waste	26	15	54	19	5	6	36	85
Cotton, by staples:								
1-3/32 inches	1	1	---	1	4	1	---	---
1-1/16 inches	2	3	---	2	---	9	---	6
1 inch	2	3	3	2	6	5	---	---
15/16 inch	17	23	5	27	36	6	2	8
7/8 inch	49	42	38	46	49	3	62	1
13/16 inch	3	13	---	3	---	70	---	---
Total cotton	74	85	46	81	95	94	64	15
Cotton, by grades:								
Strict middling	12	17	---	6	85	9	---	---
Middling	22	28	3	32	8	32	2	3
Strict low middling	22	29	5	26	---	52	7	2
Low middling	14	6	35	9	2	---	55	3
Strict good ordinary	2	3	---	4	---	1	---	---
Good ordinary	---	---	3	---	---	---	---	7
Unspecified	2	2	---	4	---	---	---	---
Total cotton	74	85	46	81	95	94	64	15
Total cotton and cotton waste	100	100	100	100	100	100	100	100

1/ Based on reports from manufacturers representing percentages of total production shown in table 17. Data are representative only of twine and cordage not manufactured from purchased yarns. An average of 1.8 percent of the total production was reported made from purchased yarns.

used in these products had increased to the equivalent of 286,000 bales as compared with 123,000 bales in 1914. This increase was proportionately greater than the increase in consumption of cotton in all industries, and as a result the percentage of the total cotton consumption used in cordage and twine rose from 2.2 percent in 1914 to 4.0 percent in 1929.

Table 20.- Total cotton consumed, and quantity consumed in cordage and twine in the United States during designated years, 1914-37.

Calendar year	Estimated consumption in cordage and twine 1/	Total consumption in all industries 2/	Percentage consumed in cordage and twine
	1,000 bales	1,000 bales	1,000 bales
1914	123	5,449	2.3
1919	131	5,920	2.2
1923	156	6,521	2.4
1925	186	6,433	2.9
1927	230	7,405	3.1
1929	286	7,050	4.1
1931	168	5,444	3.1
1933	214	6,211	3.4
1935	187	5,651	3.3
1936	3/ 234	7,104	3.3
1937	248	7,418	3.3

1/ From data in table 18.
2/ Compiled from United States Bureau of the Census Cotton Production and Distribution, Bulletin 175 and preceding issues.
3/ Estimated on basis of reports from manufacturers.

Since 1929 the upward swing in consumption of cotton in cordage and twine has been broken off and quantities used annually have ranged from as little as 169,000 bales in 1931 and 187,000 bales in 1935 to as much as 248,000 bales in 1937. Despite the low level of consumption during some of these years, a larger proportion of cordage and twine other than binder twine was made from cotton than during all years before 1929. Moreover, the percentage of total cotton consumption which was used for cordage and twine was equal to or greater than at any time before 1929. Even in absolute quantities, consumption in 1937 was greater than during any previous year except 1929. It may be concluded, therefore, that consumption of cotton in twine and cordage at least is being sustained, even though there is no definite indication of an upward trend.

Undoubtedly the most important factor influencing the consumption of cotton in cordage and twine during the last few years has been business conditions. Although fluctuations in quantities consumed have not coincided with fluctuations in business activity during every year since 1929, the abrupt decline after 1929 and the marked increase from 1935 to 1937 (see table 20) can be ascribed chiefly to this factor. In view of the magnitude of these changes it may be concluded that so far as the immediate future is concerned, the most important factor determining consumption of cotton cordage and twine is likely to be business conditions. Other factors which may be of importance are changing price relationships, changing uses, and technological developments. Although such factors may be of considerable importance, they are unlikely to influence consumption as much as changes in business activity. Changes in price relationships, unless extreme, are likely to be of only limited importance. Changing uses and technological developments may be of great importance over a long period of time, but their impact is likely to be felt only gradually.

SUMMARY AND CONCLUSIONS

Between 3 and 4 percent of the total quantity of cotton consumed annually in the United States during the years since 1925 has been used in the manufacture of cordage and twine. Consumption of cotton in this use is estimated to have averaged more than 200,000 bales annually during the last 7 years and to have totaled 248,000 bales in 1937.

In addition to cotton, a number of other fibers are used in cordage and twine. These fibers include henequen, sisal, abaca' (Manila fiber), istle (Tampico fiber), and other hard fibers; and jute, hemp, and flax. Paper also is used in the manufacture of twine. Of the total of 496 million pounds of cordage and twine manufactured in 1937, 315 million pounds was made of the various hard fibers; 100 million pounds of cotton; 50 million pounds of jute, hemp, flax, etc.; and 31 million pounds of paper.

Production of all types of cordage totaled 132 million pounds during 1937, and comprised 27 percent of the total production of cordage and twine. About one-fifth of all cordage is made from cotton and is used for clotheslines, window-sash cord, plow lines, and a variety of other uses where flexibility, softness, and appearance are of major importance. Practically all of the remainder is made from hard fibers, chiefly abaca'. These other types are used chiefly for hoisting, marine ropes, and other requirements where high tensile strength is the most needed quality. This strength either cannot be secured from cotton or can be obtained only at a much higher cost and by use of much heavier cordage. Since cotton and other types of cordage generally are used for different requirements, competition between the two is limited.

Production of all types of twine other than binder twine totaled 207 million pounds during 1937, or 42 percent of the total production of cordage and twine. In general the finest, lightest twines are made from cotton and the coarsest, heaviest twines are made from hard fibers. Jute, flax, and hemp twines occupy intermediate positions between the two, overlapping in size with the coarser cotton twines and the finer, hard-fiber twines. Of the total quantity of twines produced during 1937, 35 percent were cotton; 26 percent were hard-fiber; 24 percent were jute, hemp, flax, etc., and mixtures thereof; and 15 percent were paper.

Two-thirds of the cotton twine manufactured consists of twines used chiefly for tying purposes such as wrapping twines. These twines dominate the small-package field, are not used for heaviest packages, but compete directly with jute and other twines for tying medium-size packages. Consumption of cotton tying twines has been adversely affected by increased use of packages not requiring tying such as bags, and by gummed-paper tape, which competes on the basis of time saved clerk and customer rather than on the basis of price.

Another 13 percent of the cotton twine manufactured consists of seine and other similar twines which are used in the manufacture or repair of fishnets or as fish lines. In these uses cotton meets certain well-defined requirements which do not permit ready substitution. Consumption depends largely on fluctuations in the volume and profitability of fishing activity.

About one-fifth of the cotton twine produced is used for sewing and other miscellaneous purposes. These twines usually are identical with certain types of cotton tying twines and their use is influenced by similar technological and price comparisons with other kinds of twine. In addition their use is controlled by the requirements and conditions prevailing in each use.

An additional 32 percent or 158 million pounds of the total production of cordage and twine during 1937 consisted of one product, binder twine. Binder twine is a single-ply twine, made chiefly of sisal and henequen, which is used with binders for automatically tying bundles of the various small grains, flax and grass-seed crops, and corn during harvesting. There is no technological objection to the use of cotton for this purpose which could not be overcome, but the fibers now used are so low in price that use of cotton is precluded.

Total production of all types of cordage and twine other than binder twine has varied considerably from year to year with business conditions and other factors, but appears to have shown little or no sustained increase during the last 30 years. However, cotton's share of this production has increased from 18 percent or less before 1925 to 29 percent in 1937. Production of binder twine has declined tremendously since 1914 as a result of declining exports, increased imports, and declining consumption attendant upon decreased acreage of small-grain crops and increased use of combines.

According to reports received from manufacturers, an average of 1.18 pounds of cotton was used for each pound of cotton cordage and twine manufactured in 1937. Of the total cotton reported used, slightly more than one-fourth was cotton waste and slightly less than three-fourths was cotton lint. More than 40 percent of the waste used was card strips and more than 20 percent was comber waste. Most of the cotton lint used was of seven-eighths of an inch or fifteen-sixteenths of an inch staple and more than half was strict low middling in grade. The percentage of waste and grade and staple of cotton used varied with the type of product.

Undoubtedly business conditions have been the most important factor influencing the consumption of cotton in cordage and twine during the last few years, and this factor is likely to continue to be most important in the immediate future. Other factors of importance are changing price relationships, changing uses, and technological developments. Changes in price relationships, unless extreme, are likely to be of only limited importance. Changing uses and technological developments may be of great importance over a long period of time, but their effect is likely to be felt only gradually.